LA-UR-17-28057

Title:	Refinement of Measurement Technique Using Delayed Neutrons to Determine Enrichment of Shielded Uranium (NA-22 Project)
Author(s):	Frame, Emily Anne Andrews, Madison Theresa Myers, William L.
Intended for:	E. Frame group meeting at Berkeley
Issued:	2017-09-07

Refinement of Measurement Technique Using Delayed Neutrons To Determine Enrichment of Shielded Uranium (NA-22 Project)

Emily Frame[1,3], Madison Andrews[1], and Bill Myers[2]

Los Alamos National Laboratory

[1]X-Computational Physics Division (XCP)

Monte Carlo Methods, Codes, and Applications Group (XCP-3)

[2]Nuclear Engineering and Non-Proliferation (NEN-2)

[3]University of California, Berkeley

Department of Nuclear Engineering

LA-UR-XX-XXXX

Presentation Outline

- **Project Motivation and Goals**
- **Scientific and Technical Approach**
- **My Contribution – MCNP6 Simulations**
  - Research Overview and Motivation
  - Research Approach
  - Results
  - Future Work
- **LANL Opportunities**

Project Motivation and Goals

Project Overview and Goals

- The goal of this project is to demonstrate and develop a non-destructive measurement technique for determining uranium enrichment of bulk samples using active delayed neutron re-interrogation [1]

- This work builds on proof of principle measurements demonstrated at Los Alamos to improve and refine analysis techniques [1]

Scientific and Technical Approach

Why Use Active Interrogation for Detection of HEU?

- **Passive detection of HEU is difficult**
  - U-235 has a low spontaneous fission rate AND
  - Emits low-energy gammas which can be easily shielded

- **Active interrogation provides unique and strong signatures that can aid in the detection and identification of HEU. Such signatures include:**
  - Prompt Neutrons
  - Prompt Gammas
  - Delayed Neutrons
  - Delayed Gammas

Delayed Neutron Re-interrogation Technique

- Repetitious interrogation using a pulsed active source creates an intrinsic steady-state source of delayed neutrons [2]
- Once the active source is turned-off, the neutron response is being driven by the time-dependent decreasing population of delayed neutron precursors [2]
- U235 and U238 have distinctive delayed neutron emission properties
- Uranium enrichment can be estimated by the examining the shape and time behavior of the delayed neutron response

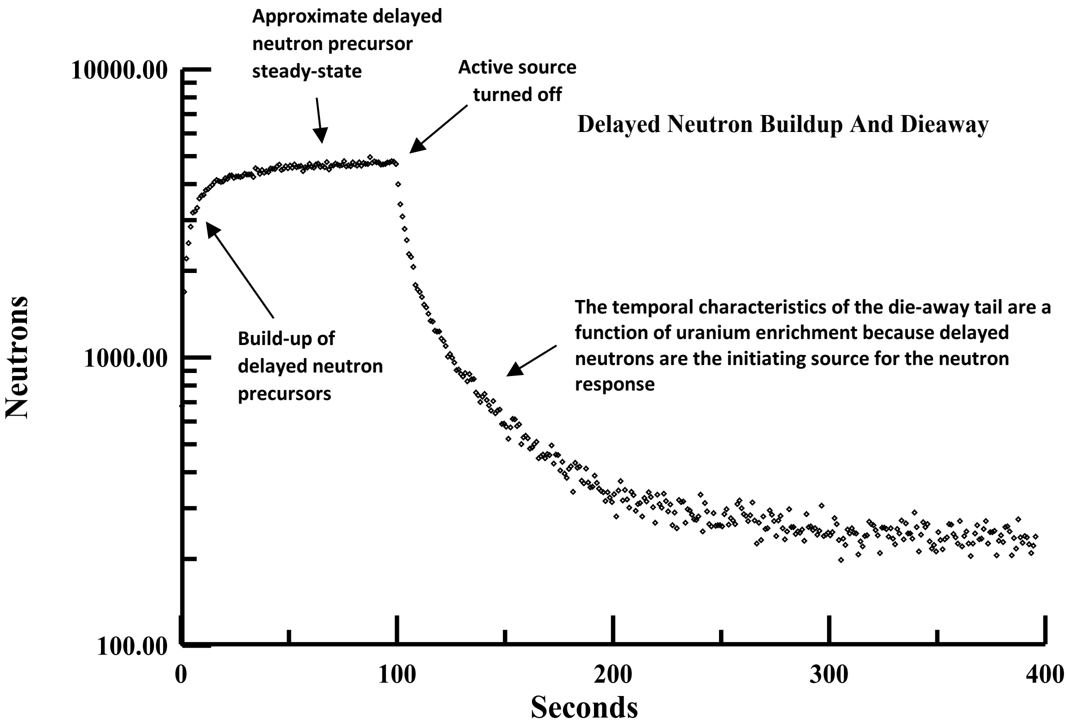

Fig.1: Time-dependence of neutron response illustrating delayed neutron buildup, equilibrium, and die-away for an active measurement of 91% enriched U235 oxide sample interrogated by pulsed 14-MeV neutrons [2]

Current Experimental Setup

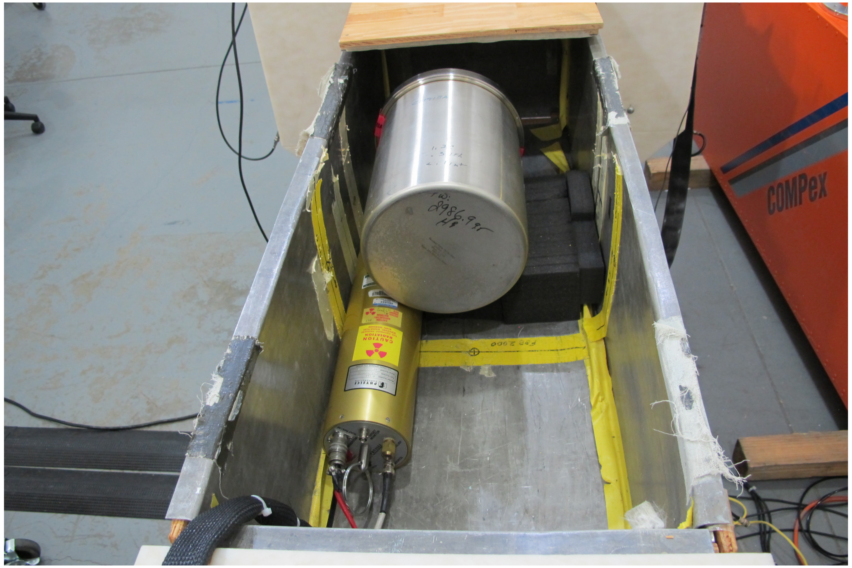

Fig.2: Experimental setup of D-T generator and uranium sample

Fig.3: Experimental setup of Brunson-Coop Counter and polyethylene vessel housing D-T generator and uranium sample

- **Active Source:** D-T 14-MeV Neutron Generator

- **Target:** uranium samples of varying enrichment (depleted to HEU)

- **Neutron Detector:** Brunson-Coop Counter (He-3 tube arrays)
  - High efficiency detector for benchmarking measurements.
  - Will use MC-15 in field

My Contributions

MCNP6 Simulations

Research Overview and Motivation

- **Project: Refinement of Measurement Technique Using Delayed Neutrons to Determine Enrichment of Shielded Uranium**
  - Includes the development of robust simulation tools that can aid in the interpretation of acquired data when measurements are taken in the field
  - MCNP is one simulation tool which will be incorporated
- **To have confidence in simulation capabilities, we are comparing MCNP6 to controlled measurements taken under known conditions. We would like to identify:**
  - If MCNP6 predicts the differences in the delayed neutron die-away
  - How varying irradiation times and SNM compositions effect the observed die-away

Research Approach

- **MCNP6 has two options for delayed neutron production:**
  1. Library
     - Uses ENDF data (Keepin 6-group delayed neutron data)
  2. Model
     - Uses a CINDER'90 transmutation code

- **Goal**
  - Determine which option best predicts measured data

- **Approach**
  - Simulate active interrogation measurements in MCNP6 using both the library and model options
  - Compare simulations to experimental data

Results: Model vs. Library

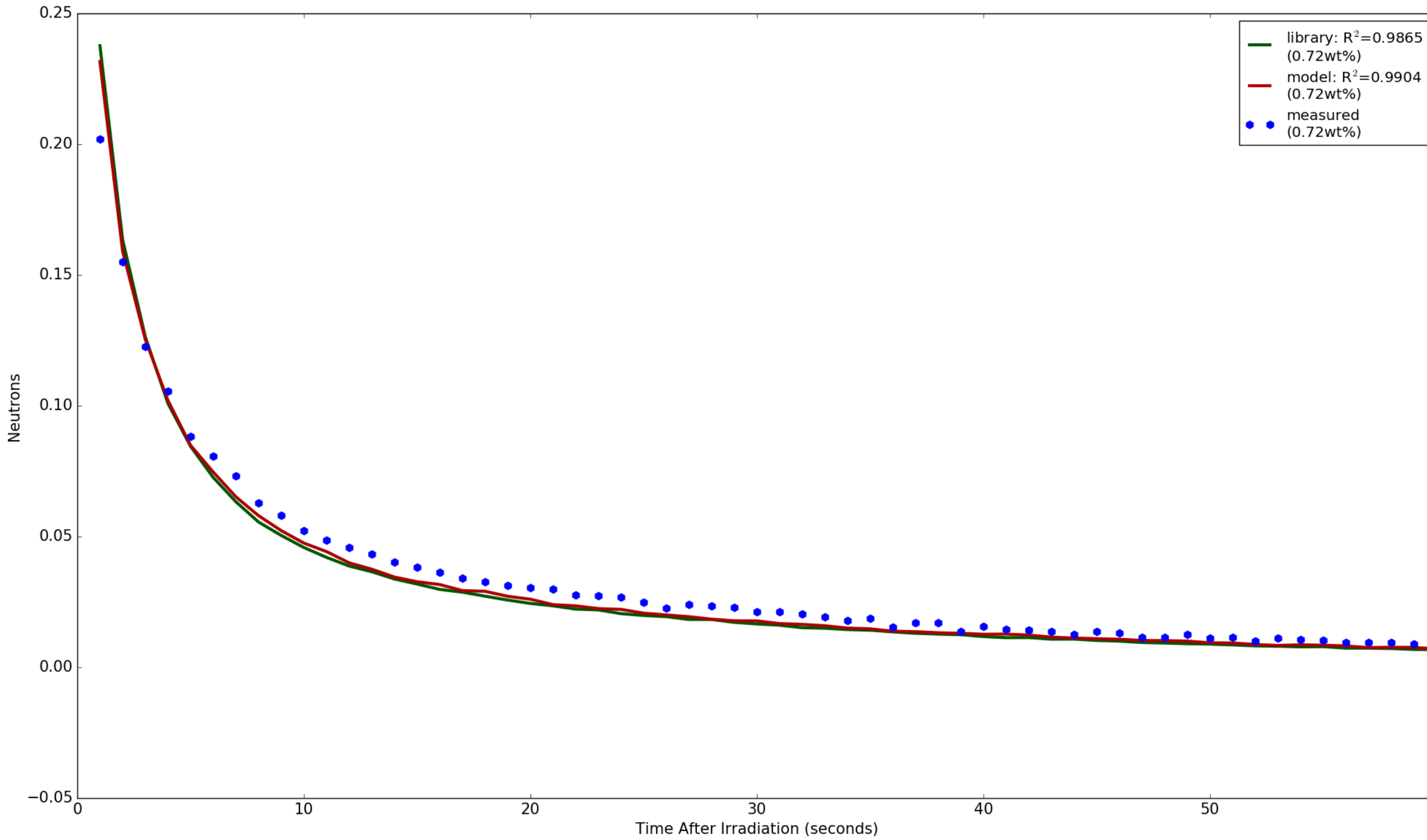

Fig. 4: Simulated vs measured delayed neutron die-away for natural uranium after being irradiated for 100 seconds with a DT neutron generator

Results: Varying Enrichments

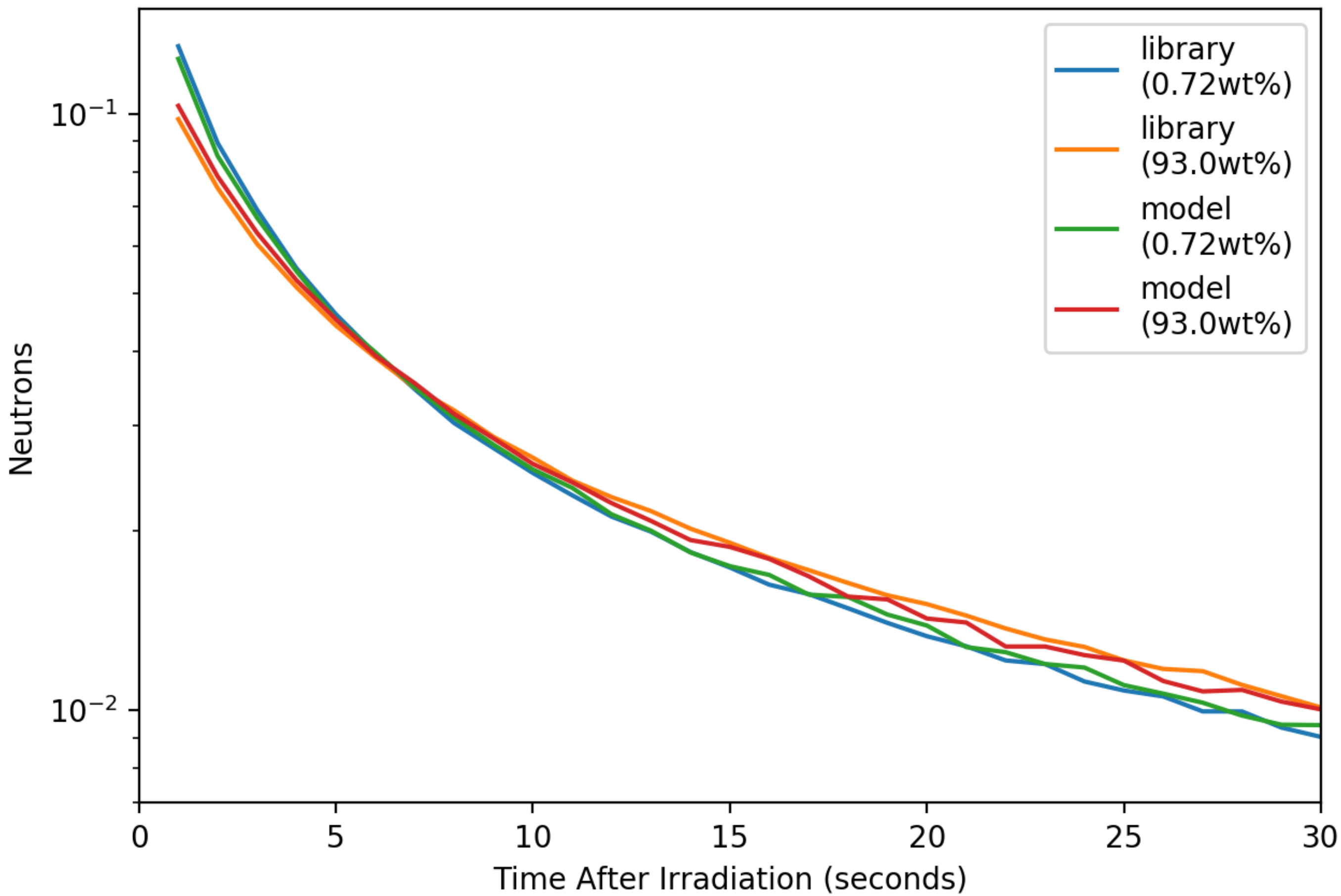

Fig. 5: Simulated die-away for natural and highly-enriched uranium, 100-second irradiation

Results: Varying Irradiation Times

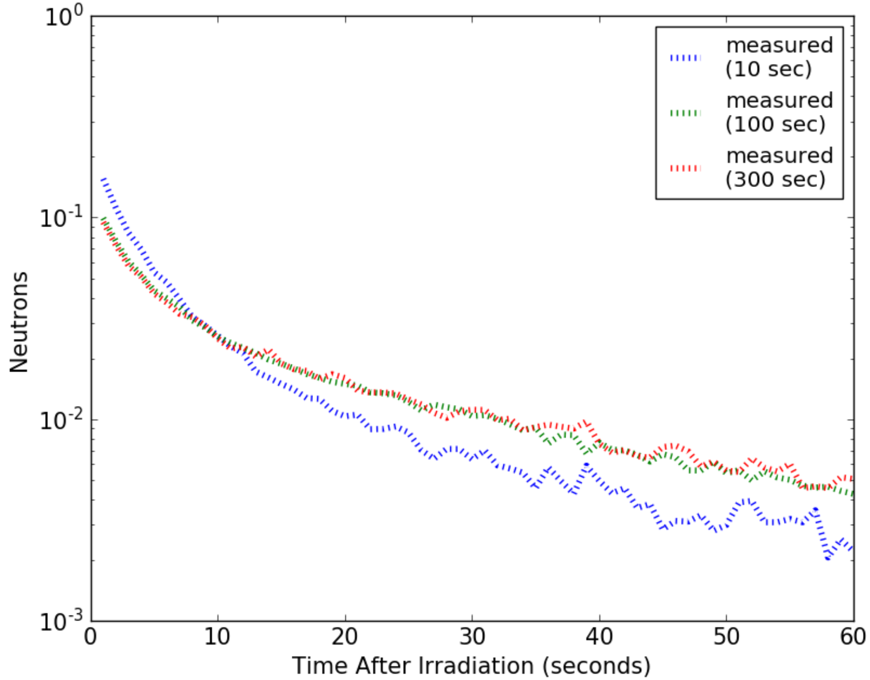

Fig. 6: Measured die-away for various irradiation times

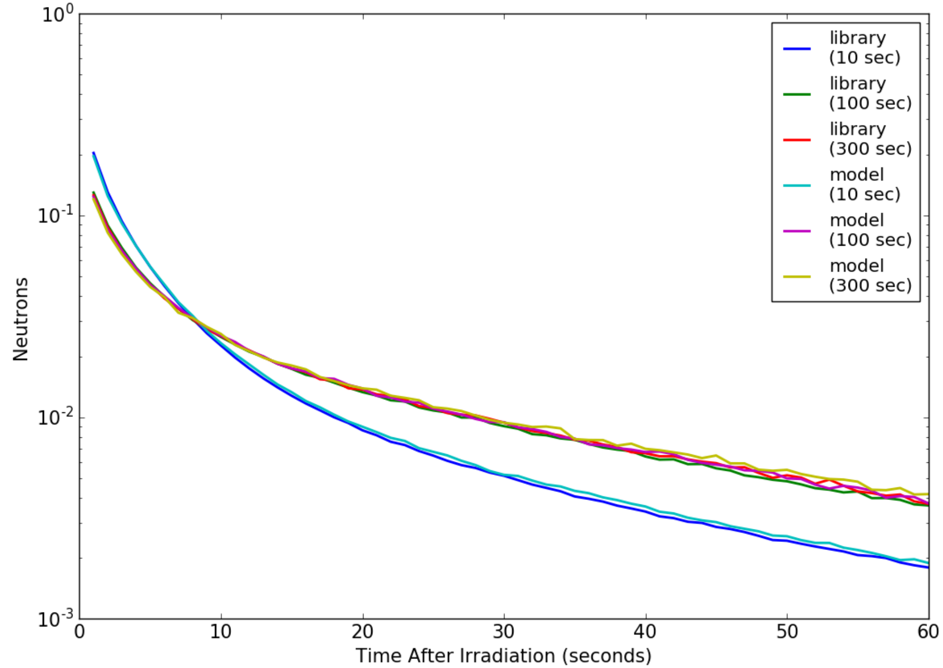

Fig. 7: Simulated die-away for various irradiation times

Future Work

- Talk with experimentalists and do more comparisons between measurements and simulations
- In-depth research on the delayed neutron options available in MCNP6
- Model the detector arrays and efficiencies and incorporate them into MCNP6 simulations
- Turn work into a Master’s project
- Submit a journal/conference paper

LANL Opportunities

LANL Opportunities

- NA-22 Active Interrogation Project
- NSSC-LANL Keepin Nuclear Nonproliferation Summer Program
- IAEA Nuclear Nondestructive Analysis Training
- Subcritical measurements at the Device Assembly Facility at the Nevada Test Site
- Southwest adventures in Santa Fe, Carlsbad Caverns, Colorado, Las Vegas, Abiquiu, and many more

Fig. 8: Me participating in BeRP ball measurements at the DAF

References

[1] Melton, S.G. *Refinement of the Measurement Technique Using Delayed Neutrons to Determine Enrichment of Shielded Uranium*. Nuclear Security Applications Research and Development Portfolio Review NSARD 2017. Los Alamos National Laboratory. April, 2017.

[2] Myers, W.L and Melton, S.G. *Refinement of the Measurement Technique Using Delayed Neutrons to Determine Enrichment of Shielded Uranium*. Proposal submitted to the NNSA, Defense Nuclear Nonproliferation Research and Development. Los Alamos National Laboratory. 2016.